

Abstract title (150 characters)

The effect of carpark traffic on pollutants yield from first flush stormwater runoff

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Keywords (max 6): pollutant loads, impervious surfaces, urban carparks, heavy metals, total suspended solids, vehicular traffic

Brief bio (600 Characters): Salina Poudyal is a PhD student in the Department of Civil and Natural Resources Engineering at the University of Canterbury, New Zealand. She is focusing her research on “monitoring contaminant loads and particle size distribution in urban runoff for the evaluation of suitable stormwater filter devices for urban carparks.”

Summary (700 characters): Vehicular traffic contributes significantly to pollutant buildup in urban carparks and the resulting storm wash-off needs to be treated before it is discharged into receiving waterways. First flush samples from 20 storm events were analyzed to investigate TSS and heavy metal discharge from three urban carparks with different traffic conditions. TSS and total Zn loads in an industrial carpark were found to be higher than in a university and a hospital carpark; however, dissolved metals concentrations were higher for the latter two sites. Results indicate that the design of stormwater filter devices needs to suit carpark characteristics and that a “one size fits all” approach is not adequate.

1. Introduction (6000 characters excluding summary)

Carparks are typically impervious and, like roads, represent a major source of stormwater pollutants such as TSS and heavy metals (Gobel et al., 2007). Traffic in urban areas has been identified as an important contributor of pollutants with specific sources including the wear and tear of car bodies and engines, abrasion of brakes and tires and exhaust emissions (Gunawardana et al., 2012; Herngren et al; 2006). In Christchurch, the majority of the stormwater runoff from carpark surfaces is discharged, untreated, directly into urban waterways. During a storm, pollutant loads are substantially higher in the initial period which is commonly known as first flush (FF). Understanding the first flush behavior is critical since most treatment options are designed to accommodate the initial portion of runoff events (Deng et al. 2005). In New Zealand, there is a lack of information on quantifying how land use characteristics, such as vehicular traffic, influence pollutant loads in stormwater runoff during the first flush. The objective of this study was to understand the effect of vehicular traffic on first flush pollutant loads from carparks of a hospital, a university, and an industrial complex.

2. Materials and Methods

First flush (FF) samples were collected by deploying Nalgene™ Storm Water Samplers (1 L HDPE). In this research, first flush was defined as the first 1-L sample collected at the beginning of a rainfall event. Twenty storm events were monitored from Sep 2015 to Nov 2016 from the three different carpark surfaces (mainly asphalt) representing different traffic characteristics (Table 1) under various antecedent dry days conditions (ADD). The average, minimum, and maximum ADD were found to be 6, 0.25, and 20.18 days

respectively. At the hospital, 11 storm events were sampled when the carpark was operational (active carpark) and 9 storm events were sampled after the carpark shut down (passive carpark). The rainfall characteristics for all sites were similar which ensured that rainfall factors would not significantly contribute to any difference in observed stormwater runoff quality between sites. All samples were transported to the laboratory for chemical analysis within the 24 hours of collection.

Tab 1. Land use characteristics and estimated daily traffic from urban car parks

Land uses	Estimated average daily ¹ traffic	Characteristics of vehicles	Carpark area (m ²) contributing to sampling sump ²
University	900 vehicles/day	Private cars and occasionally trucks for loading/unloading	5036
Hospital	300 vehicles/day	Private cars and occasionally buses and trucks	1752
Industrial	>1000 vehicles/day	Trucks (mainly 16-wheeler), vans and private cars	3042

¹ total parking lots were surveyed during the site visit. Total vehicle count was estimated using data logger at university and field observation at other two car parks.

² carpark areas were estimated using ArcGIS 10.3

3. Results and discussion

3.1 TSS loads

TSS loads in the first flush from the industrial carpark were at least one order of magnitude higher than from the other two car parks (Fig1). TSS accumulated on the industrial carpark is influenced by the nature and frequency of vehicular traffic. The Industrial site had higher traffic count as compared to other two car parks studied with an average daily traffic of >1000 where approx. 20% of total vehicle were mainly 16-wheeler trucks. Results suggest that vehicle traffic and types have a significant effect on TSS loadings. Other factors, such as topography (i.e. hospital carpark is close to hills), could affect TSS loadings as well.

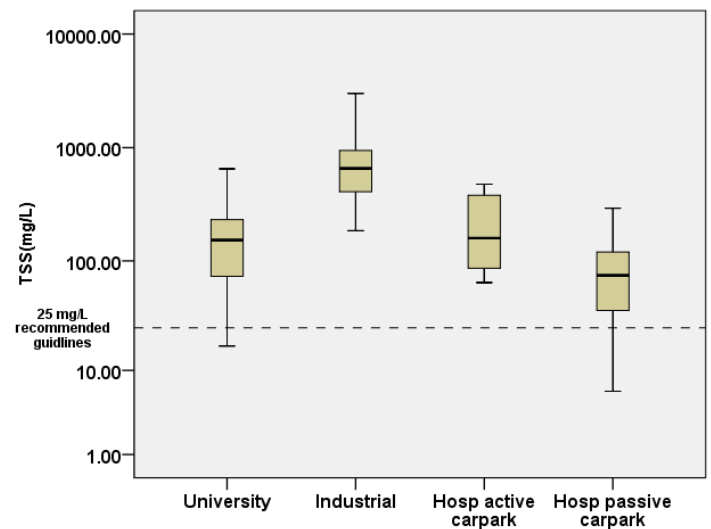


Figure 1: Variation of TSS loads from a university, industrial and hospital (active and passive) car park.

3.2 Metal-to-metal species ratios

The industrial carpark had the highest total Zn to total Cu and total Zn to total Pb ratios (16:1 and 18:1 respectively). The higher ratio at the industrial carpark indicates relatively higher rates of wear and tear of larger vehicles and other traffic behavior. The total Zn to total Cu ratios at the university and hospital (active) carparks are lower and similar, consistent of small vehicle wear and tear.

Tab. 2. Median metal to metal species ratios

Carpark	total Zn to total Cu	total Cu to total Pb	total Zn to total Pb
University	8:1	3: 1	24:1
Hospital active	9:1	1:1	10:1
Hospital passive	6:1	2:1	11:1
Industrial	16:1	1:1	18:1

3.3 Percentage partitioning

The highest percentage of a dissolved Zn was found to be 69% at the hospital active carpark, followed by university and hospital passive carparks. Dissolved Cu ranged from 20% to 52%. A smaller percentage (below 11%) of dissolved Pb was measured for all carparks. The hospital active carpark had the highest percentage of dissolved metals as compared to the two other carparks.

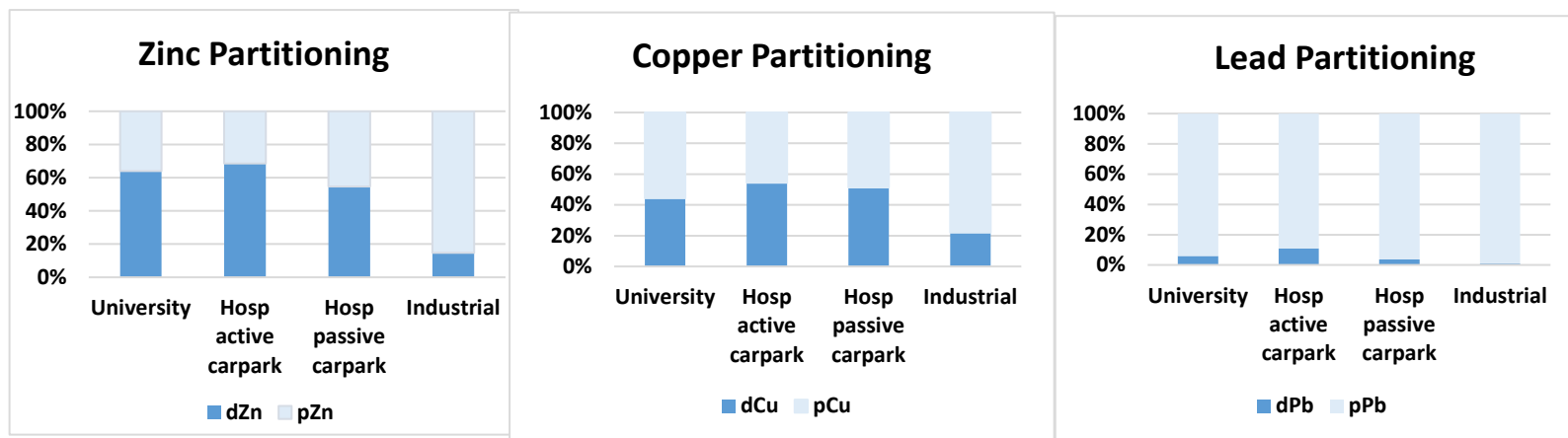


Figure 2: Dissolved (dZn, dCu, and dPb) and particulate (pZn, pCu, and pPb) metal partitioning for each carpark studied.

3. Conclusion

Irrespective of the carpark size, the nature and frequency of vehicles involved have a strong influence on TSS loads and metal-to-metal species ratios during the first flush in urban carparks. The highest percentage

of dissolved metals at the hospital carpark revealed that partitioning is likely to be influenced by various other factors such as ion exchange, rainfall pattern or pH rather than only traffic patterns or catchment area. The findings of this study show the importance of considering carpark characteristics while selecting or designing stormwater treatment devices.

Acknowledgements

The authors gratefully acknowledge the support of Robert Stainthorpe for ICP-MS analysis and Peter McGuigan for equipment set up in the field.

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